

The Monetary Model of the Exchange Rate: A Structural Interpretation

Mathias Moersch*

Dieter Nautz†

January 21, 1998

Abstract

We emphasize the importance of properly identifying the long-run relations underlying the monetary model of the exchange rate. The separate estimation of long-run money demands leads to a “structural” error correction equation which allows an interpretation of the various channels affecting the exchange rate in the monetary model. We apply this approach to the analysis of the DM/Dollar exchange rate where the structural model yields better results than various alternative forecast strategies, among them a random walk.

*DG Bank, Economics Department, D-60265 Frankfurt/Main.

†FU Berlin, Institut f. Statistik und Ökonometrie, Boltzmannstr. 20, 14195 Berlin, Germany, e-mail: nautz@wiwiss.fu-berlin.de. We thank Uwe Hassler, Michael Heise and Jürgen Wolters for providing very helpful comments and suggestions. Research support by the Deutsche Forschungsgemeinschaft (DFG), Sonderforschungsbereich 373, “Quantifikation und Simulation Ökonomischer Prozesse”, at the Humboldt-University at Berlin, is gratefully acknowledged.

1 Introduction

The monetary model has a long and checkered history as a tool to model and forecast exchange rate behavior. What has led to renewed interest in the model are recent advances in econometric techniques and a better empirical understanding of the behavior of some of the key variables in the model. Especially MacDonald and Taylor (1994) relying on recent cointegration techniques, show that the monetary model is useful in forecasting exchange rates. This has challenged the well-known result obtained by Meese and Rogoff (1983) that the monetary model is inferior to a random walk out-of-sample.

The monetary model of exchange rate determination is based on two main assumptions. They are first, the existence of stable money demand functions and second, purchasing power parity (PPP). With an emerging consensus that there is indeed reversion towards PPP, albeit at very slow rates (Rogoff, 1996) and the successful estimation of long-run money demand functions for many countries, there is now also a firmer empirical base for the theoretical underpinnings of the model.

In this paper we build on these methodological and empirical advances but differ from previous research by suggesting a more structural interpretation of the monetary model of the exchange rate. In Section 2, we emphasize the importance of properly identifying the underlying long-run relations of the economic system. In particular, we suggest to base the empirical analysis of the monetary model on carefully specified money demand functions. This avoids various pitfalls of the reduced form approach commonly applied in the empirical literature. For example, the joint estimation of several long-run relations inherent in the reduced form approach usually leads to highly implausible income and interest rate elasticities. The separate estimation of the underlying long-run relations leads to a “structural” error correction equation in which the disequilibria resulting from the long-run money demands and PPP have a separate and independent effect on the exchange rate. This allows an interpretation of the various channels affecting the exchange rate in the monetary model.

In Section 3 we apply the monetary model to the analysis of the DM/Dollar exchange

rate where the structural model yields better results than a reduced form in explaining the exchange rate. Moreover, the error correction equation based on the reduced form approach is shown to rest on invalid parameter restrictions. Finally, out-of-sample forecasts demonstrate that the structural error correction model outperforms several alternative forecast strategies, among them a random walk.

2 The Monetary Model: Structural versus Reduced Form

If purchasing power parity (PPP) holds in the long run, then there is a long-run equilibrium

$$e = p - p^* \quad (1)$$

where e denotes the log of the exchange rate (expressed as domestic currency per unit of foreign currency), and p and p^* are the logs of the home and foreign price levels (here and in the following an asterisk denotes the corresponding foreign variable). Empirical tests typically involve cointegration analysis, since the nonstationarity of prices and exchange rates implies that for PPP to hold (1) is a cointegrating relation, see e.g. Steigerwald (1996). Following the Engle–Granger representation theorem for cointegrated time series, long-run PPP implies that the short run dynamics of the exchange rate are characterized by an error correction equation where the exchange rate should adjust to the stationary deviations from PPP. In the trivariate system (e, p, p^*) , this equation can be stated as

$$\Delta e_t = \gamma[e - (p - p^*)]_{t-1} + \text{lags}(\Delta e, \Delta p, \Delta p^*) + \varepsilon_t \quad (2)$$

where $[e - (p - p^*)]_{t-1} =: ec_{t-1}^{PPP}$ is the error correction term indicating the observed deviation from long-run PPP. According to (2), deviations from PPP are the only economic disequilibria the exchange rate responds to. Not surprisingly, this adjustment process is too simplistic to account for the complexity of exchange rate dynamics, and exchange rate forecasts based on (2) alone typically lead to disappointing results.

The monetary model of exchange rate determination considers a richer set of economic long-run equilibria. Assuming stable long-run money demand functions for the domestic

and foreign economy that are linked by PPP, the basic monetary model relies on three cointegrating relationships:

$$m - p = \alpha y + \delta i + ec^m \quad (3)$$

$$m^* - p^* = \alpha^* y^* + \delta^* i^* + ec^{m^*} \quad (4)$$

$$e = p - p^* + ec^{ppp} \quad (5)$$

where m, y , are the logs of money supply and income, respectively, i is an interest rate measuring the opportunity cost of holding money, and the ec 's are the stationary deviations from the corresponding long-run equilibria. Therefore, it is a distinguishing feature of the monetary model that the error correction equation for the exchange rate may involve not only one but three error correction terms related to the long-run relations stated above:

$$\Delta e_t = \gamma_{ppp} ec_{t-1}^{ppp} + \gamma_m ec_{t-1}^m + \gamma_{m^*} ec_{t-1}^{m^*} + \text{lagged differences} + \varepsilon_t. \quad (6)$$

In the spirit of Konishi et al. (1993), the monetary model of exchange rate determination thus generalizes the usual partial cointegration framework to a more general equilibrium setting. It gives further insight into the process of exchange rate determination if and only if monetary disequilibria have an impact on the exchange rate, i.e. if $\gamma_m \neq 0$ or $\gamma_{m^*} \neq 0$. In this case, equation (2), which ignores the influence of money markets, is misspecified and resulting forecasts are misleading. Plausible values of the adjustment parameters are $\gamma_{ppp} < 0$, $\gamma_m \geq 0$, and $\gamma_{m^*} \leq 0$. For example, if $ec^{m^*} > 0$ then there is an excess supply for U.S. currency which should lead to a depreciation of the Dollar and, thus, to a decrease of e . It is worth emphasizing that the monetary model implies no additional restrictions on the adjustment parameters in (6). In particular, there is no reason why the strength of adjustment towards the three different monetary long-run relations should be equal, i.e. the absolute values of γ_m , γ_{m^*} and γ_{ppp} may well differ.

A straightforward test of the monetary model therefore involves testing the significance and sign of the monetary adjustment parameters $\hat{\gamma}_m$ and $\hat{\gamma}_{m^*}$ in an equation such as (6). Obviously, the validity of such an exercise requires a careful estimation of the underlying money demand functions. However, to date the issue of sensibly specifying the underlying long-run relations has not received the attention it deserves in the empirical literature on

the monetary model. In fact, it is usually circumvented by estimating a so-called reduced form equation of the monetary model

$$e_t = \beta_0 + \beta_1 m_t + \beta_2 m_t^* + \beta_3 y_t + \beta_4 y_t^* + \beta_5 i_t + \beta_6 i_t^* + u_t, \quad (7)$$

where both price levels are eliminated by substituting (5) in (3)–(4). It follows that $\beta_1 = -\beta_2 = 1$, $\beta_3 = \alpha$, $\beta_4 = -\alpha^*$, $\beta_5 = \delta$, and $\beta_6 = \delta^*$. Since $u_t = ec^{ppp} - (ec^m - ec^{m^*})$, it is also implied that (7) is a cointegrating relation if and only if the three basic long-run relations of the monetary model (3), (4) and (5) hold. As a preliminary test of the monetary model, the presence of cointegration in the reduced system $(e, m, m^*, y, y^*, i, i^*)$ has been established for many countries using the cointegration test introduced by Johansen (1988), see e.g. MacDonald and Taylor (1991, 1994), Moosa (1994), Kim and Mo (1995), Diamandis and Kouretas (1996), and Choudhry and Lawler (1997). In these papers, exchange rate forecasts are made by use of an error correction equation which entails the estimated \hat{u}_{t-1} as single error correction term.¹

Several issues remain unresolved in this type of analysis. First, even though the cointegration rank of the reduced system is one, often more than one cointegrating vector is found, see e.g. MacDonald and Taylor (1994). This problem, presumably due to the shortcomings of the Johansen *test* in small samples, forces the researcher to somewhat arbitrarily identify the “relevant” cointegrating vector.²

Second, in the reduced form approach, long-run income and interest rate elasticities of two separate money demand functions are estimated simultaneously in a high-dimensional system. As a result, the Johansen *estimator* may become less reliable in finite samples since its exact distribution does not have finite moments, see Phillips (1994). Therefore, the identification of long-run money demands has not much chance of success, and long-run income and interest rate elasticities implied by the estimated cointegrating relation (7) are usually highly implausible.³ Put differently, it can be expected that the monetary

¹Thus, although the above contributors emphasize the merits of the multivariate Johansen procedure, they basically follow the traditional two step procedure introduced by Engle and Granger (1987).

²Reinsel and Ahn (1992) therefore suggest a finite sample correction of the Johansen test statistic.

³For example, having found three cointegrating vectors MacDonald and Taylor (1994, p.283) base their

disequilibria ec^m and ec^{m^*} are not appropriately reflected in the estimated error correction term \hat{u}_t of the reduced system.

Third, the reduced form approach leads to restrictions on the adjustment parameters in the error correction equation of the exchange rate which are not implied by the monetary model. Since (7) is the only cointegrating relation in the reduced system, error correction equations used in the reduced form approach only include \hat{u}_t as error correction term. Thus, exchange rate forecasts are based on an equation of the following form (ignoring lagged differences):

$$\Delta e_t = \gamma_r(u_{t-1}) + \varepsilon_t = \gamma_r(ec^{ppp} - ec^m + ec^{m^*}) + \varepsilon_t. \quad (8)$$

Comparing (8) with its structural counterpart (6) reveals that the adjustment of the exchange rate is restricted to $\gamma_{ppp} = -\gamma_m = \gamma_{m^*}$. Thus, the reduced form approach assumes that the adjustment is of equal strength for each underlying long-run relation.

In view of these problems of the reduced form approach, our more structural approach to the monetary model emphasizes the sensible specification of the underlying economic long-run relations. In the following empirical example, we therefore estimate long-run money demands referring to the relevant subsystems (m, p, y, i) and (m^*, p^*, y^*, i^*) . Moreover, we analyze whether there are additional, i.e. more than three, long-run relations in the system. In our example, the expectations hypothesis of the term structure and uncovered interest parity are natural candidates. Having established the relevant economic long-run relations, the estimated disequilibria are used to estimate an error correction equation for the exchange rate such as (6). This approach not only assures more reliable income and interest rate elasticities, but also affords tests of the relative size and importance of the adjustment parameters, thereby addressing another possible source of misspecification in the exchange rate forecast equation. Finally, the observed error correction terms can be explicitly linked to exchange rate movements, thus allowing a clearer economic interpretation.

exchange rate forecasts on the vector which corresponds to the *second* largest eigenvalue. They argue that the resulting equation would not do “great violence” to the monetary model, but the implied long-run income elasticity close to zero for the U.K. and the incorrectly signed interest rate effect on money demand for the U.S. indicate the problems with such an approach.

3 An Empirical Example

3.1 Data

Data is quarterly and runs from 83:1 until 96:3. 96:4 to 97:3 is set aside for out-of-sample prediction exercises. The starting date is chosen in order to avoid structural breaks in the long-run relations due to the monetarist experiment in the United States and increased capital mobility in Germany, see Juselius (1996). Germany is the home country and e , the exchange rate, is defined as DM/\$. m , the money supply measure for both countries, is M1, y , the activity measure is real GDP. Money, real GDP and the consumer price index p are seasonally adjusted. For estimating money demand functions, the proper measurement of the opportunity cost for holding money is critical to obtaining sensible results. In particular, short- and long-term interest rates may affect the rate of return on alternatives to money. We therefore consider not only the influence of the German money market rate (r) and the U.S. federal funds rate (r^*) but also the influence of the corresponding 10-year bond rates, denoted by R and R^* . All variables except for the interest rates are entered in logs. All data is from the FERI Database.

3.2 Money Demand Functions

The money demand functions for the two countries are estimated using the single-equation conditional error correction framework introduced by Stock (1987). This approach has the advantage that it directly includes the short run dynamics by incorporating lagged differences and lagged levels in one equation. We regress $\Delta(m-p)_t$ on $(m-p)_{t-1}, y_{t-1}, r_{t-1}, R_{t-1}$, all differences of these variables up to lag order four and an intercept term. Following Wolters et al. (1998), the shifts in the levels of the German money and income series due to German unification are captured by a step-dummy D_t which equals one for unified Germany and zero before. In Germany, income velocities for broad and narrow money supply show a significant downward trend. We therefore included the linear time trend t

as an additional variable.⁴

Applying a general-to-specific procedure, we develop the following parsimonious dynamic specification for German money demand:

$$\begin{aligned} \Delta(m-p)_t = & \underset{(2.97)}{-0.22} \left[(m-p-y)_{t-1} + 2.54R_{t-1} - 0.00866(t-1) + 0.075D_{t-1} \right] \\ & - \underset{(2.95)}{1.38} \Delta r_{t-1} + \underset{(9.16)}{0.16} \Delta D_t - \underset{(2.92)}{1.07} + \hat{\varepsilon}_t \end{aligned} \quad (9)$$

Sample: 83 : 1 – 96 : 3 $\bar{R}^2 = 0.71$ $LM(1) = 0.09$ [0.76] $Q(12) = 15.35$ [0.22] $HW = 0.99$ [0.46]

Notes: t-values are given in parantheses and p-values in brackets. $LM(1)$ gives the F-value of the Lagrange multiplier test against first order serial correlation, $Q(12)$ denotes the Ljung–Box statistic against serial correlation up to 12-th order, and HW belongs to the White-test against heteroskedasticity.

The diagnostic statistics computed from the residuals indicate that equation (9) adequately accounts for serial correlation and heteroskedasticity. The estimated deviation from long-run money demand, $\hat{\varepsilon}^m$, appears in the square brackets. (9) leads to the following long-run money demand:

$$(m-p)_t = y_t - 2.54R_t - 0.075D_t + 0.00866t. \quad (10)$$

The estimated coefficients show plausible signs. Estimating an unrestricted version of (10), we could not reject the null hypothesis that the long-run income elasticity equals one. In line with Brüggemann and Wolters (1997), we find that it is the bond rate (R) which influences the demand for narrow money in the long run. The short-term rate (r), however, plays an important role in the money demand's short run dynamics. When the Bundesbank determines its yearly money growth targets for M3, it adds one percentage point to account for the velocity trend. Similarly, (10) implies a yearly decrease in M1-velocity of about 3%.

⁴Wolters et al. (1998) capture the velocity-trend of German M3 by adding the inflation rate in the long-run equation. In our sample, however, the inflation rate is not significant.

For the United States, using again the general-to-specific procedure, we obtain:

$$\begin{aligned}\Delta(m-p)_t^* &= \underset{(4.37)}{-0.79} \Delta R_{t-1}^* + \underset{(6.21)}{0.52} \Delta(m-p)_{t-1}^* + \underset{(3.48)}{0.32} \Delta(m-p)_{t-3}^* - \underset{(4.00)}{0.61} \\ &\quad - \underset{(4.00)}{0.11} \left[(m-p-y)_{t-1}^* + 1.57r_{t-1}^* \right]\end{aligned}\quad (11)$$

Sample: 83 : 1 – 96 : 3 $\bar{R}^2 = 0.77$ $LM(1) = 0.05$ [0.83] $Q(12) = 14.42$ [0.27] $HW = 1.33$ [0.25]

Notes: For further explanation see equation (9).

where the estimated equilibrium error \hat{e}^{m*} appears again in the square brackets. Accordingly, the U.S. long-run money demand is given by

$$(m-p)_t^* = y_t^* - 1.57r_t^*. \quad (12)$$

In accordance with the results obtained by Hoffman and Rasche (1996), we found evidence for a long-run income elasticity of one. Again, the interest rate effect is plausibly signed. However, the role of the interest rates has changed: in the U.S. equation it is the short-term interest rate which appears in the long-run relation while the bond rate has only a short run effect.

3.3 Purchasing Power Parity and Interest Rate Differentials

Rather than estimating the coefficients for the purchasing power parity condition, coefficients of one are imposed on the price levels. This is done because there is evidence for PPP over fairly long time intervals but not over shorter time spans, see Rogoff (1996). Estimating PPP may thus introduce incorrect coefficient estimates because of an insufficiently long sample period, see Fritsche and Wallace (1997).⁵ We therefore define $ec_t^{ppp} = e_t + p_t^* - p_t$.

So far, we have found three independent cointegrating relations in the system of eleven variables including the exchange rate, and, for both countries, money supplies, prices,

⁵Note however that for our sample an estimation of the PPP equation (1) would lead to coefficients close to one.

incomes, and short- and long-term interest rates. In order to get a well specified error correction equation for the exchange rate we have to assure that no long-run relation of the system is omitted. In particular, long- and short-term interest rates should be cointegrated according to the expectations hypothesis of the term structure, see Campbell and Shiller (1987). Specifically, if the expectations hypothesis holds, the interest rate spreads $(R - r)$ and $(R^* - r^*)$ should be stationary. In this case, the spreads have to be included in the error correction equation for the exchange rate in order to avoid a misspecification bias. However, the connection between (very) short- and (very) long-term interest rates is usually not at all as close as the expectations theory predicts. In fact, confirming the results from e.g. Zhang (1993) for the U.S. and Wolters (1995) and Hassler and Nautz (1998) for Germany, unit root and cointegration tests indicate that there is no stable relationship between short- and long-term interest rates in the two countries.⁶

The second source of additional long-run relations is uncovered interest rate parity (UIP) which implies cointegration of home and foreign interest rates of the same maturity. In particular, interest rate differentials should be stationary if UIP holds. The degree of synchronization of German and U.S. interest rate movements declines as maturities become shorter. In fact, cointegration tests suggest that there is no long-run relation between the mainly policy determined short-term interest rates in the United States and Germany, see e.g. Deutsche Bundesbank (1997). By contrast, the increasing international integration of the German bond market has reinforced the link between German and U.S. long-term interest rates, especially since the beginning of the nineties. Since then, the spread between the German and the U.S. bond rate can be viewed as stationary, see e.g. Dankenbring (1997). Therefore, the lagged bond rate differential has to be included as an additional error correction term in the exchange rate equation.

Overall, we find four independent economic long-run relations in the whole system which all may affect the exchange rate. These are related to the two long-run money demands,

⁶The cointegration properties of German and U.S. short- and long-term interest rates are already established in the empirical literature. For sake of brevity, results of cointegration tests are therefore not presented, but are available from the authors on request.

PPP and the UIP relation for the bond rates. The monetary model should thus be tested on a structural error correction equation for the exchange rate of the following form:

$$\Delta e_t = \gamma_{ppp} ec_{t-1}^{ppp} + \gamma_m \hat{ec}_{t-1}^m + \gamma_{m^*} \hat{ec}_{t-1}^{m^*} + \gamma_{uip} ec_{t-1}^{uip} + \text{lagged differences} + \varepsilon_t \quad (13)$$

where $ec^{ppp} = e - p + p^*$ and $ec^{uip} = (R - R^*)$ are the deviations from PPP and UIP and \hat{ec}^m and \hat{ec}^{m^*} are the estimated deviations from the long-run money demands defined in (9) and (11).

3.4 The Monetary Model

Based on a testing down strategy, we combined the four error correction terms with lagged differences to arrive at the following specification for the exchange rate error correction equation.

$$\begin{aligned} \Delta e_t = & \underset{(3.46)}{-0.23} ec_{t-1}^{ppp} + \underset{(5.04)}{0.77} \hat{ec}_{t-1}^m - \underset{(2.04)}{0.35} \hat{ec}_{t-1}^{m^*} - \underset{(3.74)}{2.67} ec_{t-1}^{uip} \\ & - \underset{(2.99)}{4.19} \Delta R_{t-1} + \underset{(1.74)}{2.08} + \underset{(1.40)}{0.06} \Delta D_t \end{aligned} \quad (14)$$

Sample: 83 : 1 – 96 : 3 $\bar{R}^2 = 0.47$ $LM(1) = 0.05$ [0.83] $Q(12) = 16.06$ [0.19] $HW = 1.10$ [0.38]

Notes: For further explanation see equations (9) and (13).

This equation allows a number of interesting observations concerning the adjustment mechanisms of the exchange rate and the working of the monetary model. First, all four error correction terms are statistically significant, thus confirming the economic relevance of the various adjustment mechanisms. In particular, the null hypothesis $\gamma_m = \gamma_{m^*} = 0$ stating that the monetary model provides no additional insight into the determination of the DM/Dollar exchange rate is easily rejected. Second, the error correction terms from the money demand functions have the theoretically expected opposite signs. Note that the error correction terms for PPP and the interest rate condition are correctly signed as well. Particularly, deviations from PPP caused by an increase in the U.S. price level lead to an

appreciation of the DM. Third, there is no indication that the adjustment parameters for PPP and the money demand functions are the same. Adjustment to PPP ($\hat{\gamma}_{ppp} = -0.23$) is slower than adjustment to the monetary disequilibria ($\hat{\gamma}_m = 0.77$, $\hat{\gamma}_{m^*} = -0.35$). In fact, the coefficient restriction $\gamma_{ppp} = -\gamma_m = \gamma_{m^*}$ implied by the reduced form approach is rejected at the one percent significance level: The corresponding F-statistic (5.33) leads to a p-value of 0.008. The adjustment parameter of the reduced form error correction equation (8), $\hat{\gamma}_r$, is -0.32 .⁷ Since the coefficients of ec^{ppp} and \hat{ec}^{m^*} are close to this value, forecasts from the structural and the reduced form equation will lead to similar results when the monetary disequilibrium in Germany \hat{ec}^m is small.

3.5 Forecast Evaluation

Meese and Rogoff (1983) demonstrated that a significant impact of monetary disequilibria *in-sample* does not necessarily imply a good forecasting ability *out-of-sample*. In order to assess the predictive performance of the structural error correction equation (14), we compare its out-of-sample forecasts denoted by ef^{struc} with the results from several alternative forecast strategies. First, we reestimate the error correction equation for the exchange rate restricting the adjustment parameters according to the reduced form approach, i.e. $\gamma_{ppp} = -\gamma_m = \gamma_{m^*}$. We denote the corresponding reduced form forecasts by ef^{red} . Second, forecasts are based on an equation where the impact of both monetary disequilibria is neglected (but not the impact of UIP), i.e. $\gamma_m = \gamma_{m^*} = 0$, which leads to the forecasts ef^{uip} . Third, we estimate an error correction equation where the exchange rate only adjusts to deviations from PPP, i.e. $\gamma_{uip} = \gamma_m = \gamma_{m^*} = 0$, and denote the resulting forecasts by ef^{ppp} . And finally, as a point of reference we compare these forecasts with a simple random walk model (ef^{rw}). Forecasts are dynamic in the sense that forecasts greater than one period ahead use previously forecasted values of the exchange rate as

⁷Reestimating the error correction equation under the restriction implied by the reduced form approach leads to:

$$\Delta e_t = \underset{(5.26)}{-0.32} \hat{u}_{t-1} - \underset{(4.83)}{3.29} ec_{t-1}^{uip} - \underset{(2.78)}{4.18} \Delta R_{t-1} + \underset{(4.50)}{0.10} + \underset{(0.86)}{0.04} \Delta D_t. \quad (15)$$

Table 1: Out-of-sample forecast performance

	ef^{struc}	ef^{red}	ef^{uip}	ef^{ppp}	ef^{rw}
RMSE(1)	0.039	0.059	0.008	0.029	0.033
RMSE(2)	0.033	0.051	0.071	0.099	0.116
RMSE(3)	0.054	0.066	0.092	0.134	0.157
RMSE(4)	0.052	0.062	0.133	0.186	0.206

Notes: The out-of-sample forecasts start in 96:4 and end in 97:3. $RMSE(j)$ denotes the root mean square error of the dynamic exchange rate forecast for j periods ahead, $j = 1, 2, 3, 4$.

inputs. However, for all other variables actual values are used.

The root mean square errors (RMSE) for out-of-sample forecasts (1996:4 – 1997:3) for one to four quarters ahead are presented in Table 1. With the exception of the first quarter, predictions of the monetary model in its structural form compare most favorably to those based on more restricted equations. Taking into account the observed monetary disequilibria obviously improves exchange rate forecasts of the DM/Dollar for longer horizons. In particular, the monetary model clearly beats the random walk.

Figure 1: Out-of-sample forecast performance

Especially interesting is the fact that the recent upturn of the U.S. Dollar was captured well by the monetary approach, see Figure 1. By contrast, forecasts exclusively based on deviations from PPP strongly underestimate the depreciation of the DM in 1997.

The development of the estimated monetary disequilibria terms, $\hat{e}c^m$ and $\hat{e}c^{m*}$, shown in Figure 2, helps to illustrate the economic causes of the U.S. Dollar upturn. From

Figure 2: The estimated monetary disequilibria

Notes: $\hat{e}c^m$ and $\hat{e}c^{m*}$ are the mean adjusted deviations from the estimated long-run money demands, see (9) and (11). The shaded areas indicate the German monetary union, and the out-of-sample period.

1996:3 until 1997:3 there are only minor deviations from long-run money demand in Germany which explains why in our application structural and reduced form exchange rate forecasts are broadly similar. At the same time, there seems to be a remarkable monetary disequilibrium in the United States which already explains a major part of the recent Dollar upturn.

4 Concluding Remarks

This paper shows that a structural interpretation can be given to the cointegrating relationships found in the monetary model of exchange rates. This has distinct advantages over the reduced form approach which has been applied in the empirical literature on the monetary model so far. In contrast to the reduced form approach where exchange rate forecasts are based on only one monetary disequilibrium term, the decomposition into error correction terms related to the two money demand functions, purchasing power parity and the interest rate differential allows an interpretation of the working of the monetary model. For example, according to the estimated long-run relations, the recent upturn of the Dollar was mainly due to an excess demand for U.S. currency and had little to do with adjustments to PPP. Moreover, by estimating the various components separately the imposition of additional parameter restrictions can be tested and resulting misspecification problems are avoided. In particular, we demonstrated that forecasts of the DM/Dollar exchange rate using the monetary model convincingly beat more restricted forecast equations and are clearly better than the random walk model when the forecast horizon increases.

References

- [1] Brüggemann, I. and J. Wolters. (1997), Money and Prices in Germany: Empirical Results for 1962 to 1996, *Free University Berlin, Discussionpaper Nr. 19/1997*.
- [2] Campbell, J. Y. and R. J. Shiller. (1987), Cointegration and Tests of Present Value Models. *Journal of Political Economy*, 95:1062–88.
- [3] Choudhry, T. and P. Lawler. (1997), The Monetary Model of Exchange Rates: Evidence from the Canadian Float of the 1950s. *Journal of Macroeconomics*, 19:349–62.
- [4] Dankenbring, H. (1997), The Term Structure of Interest Rates and the Uncovered Interest Rate Parity: Empirical Results for Germany and the U.S. *Humboldt-University at Berlin, SFB 373, Discussionpaper Nr. 72*.
- [5] Deutsche Bundesbank. (1997), The Implications of International Influences for Capital Market Rates. *Monthly Reports of the Deutsche Bundesbank*, July, 23–40.

- [6] Diamandis, P. F. and G. P. Kouretas. (1996), The Monetary Approach to the Exchange Rate: Long-run Relationships, Coefficient Restrictions and Temporal Stability of the Greek Drachma. *Applied Financial Economics*, 351-62.
- [7] Engle, R. F. and C. W. J. Granger. (1987), Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica*, 55:251-276.
- [8] Fritsche, C. and M. Wallace. (1997), Forecasting the Exchange Rate PPP Versus a Random Walk. *Economics Letters*, 69-74.
- [9] Hassler, U. and D. Nautz (1998), The Link between German Short- and Long-term Interest Rates: Some Evidence against a Term Structure Oriented Monetary Policy. *Jahrbücher für Nationalökonomie und Statistik*, forthcoming.
- [10] Hoffman, D. L. and R. H. Rasche, (1996), Aggregate Money Demand Functions: Empirical Applications in Cointegrated Systems. *Kluwer Academic Publishers*.
- [11] Johansen, S. (1988), Statistical Analysis of Cointegrating Vectors. *Journal of Economic Dynamics and Control*, 231-254.
- [12] Juselius, K. (1996), An Empirical Analysis of the Changing Role of the German Bundesbank after 1983. *Oxford Bulletin of Economics and Statistics*, 58, 791-819.
- [13] Konishi, T., V. A. Ramey und C. W. J. Granger. (1993), Stochastic Trends and Short-Run Relationships between Financial Variables and Real Activity. *National Bureau of Economic Research Discussion Paper No. 4275*.
- [14] Kim, B. and S. Mo (1995), Cointegration and the Long-run Forecasts of Exchange Rates, (48), *Economics Letters*, 353-59.
- [15] MacDonald, R. and M. P. Taylor. (1991), The Monetary Approach to the Exchange Rate. *Economics Letters*, 179-185.
- [16] MacDonald, R. and M. P. Taylor. (1994), The Monetary Model of the Exchange Rate: Long-run Relationships, Short Run Dynamics and how to Beat a Random Walk. *Journal of International Money and Finance*, 13:276-90.
- [17] Meese, R. A. and K. Rogoff. (1983), Empirical Exchange Rate Models of the Seventies: Do they Fit Out-of-sample? *Journal of International Economics*, 14:3-24.

- [18] Moosa, I.A. (1994), The Monetary Model of the Exchange Rate Revisited. *Applied Financial Economics*, 279-87.
- [19] Phillips, P. C. B. (1994), Some Exact Distribution Theory for the Maximum Likelihood Estimators of Cointegrating Coefficients in Error Correction Models. *Econometrica*, 57: 99-125.
- [20] Reinsel, G. C. and S. K. Ahn (1992), Vector Autoregressive Models with Unit Roots and Reduced Rank Structure: Estimation, Likelihood Ratio Tests, and Forecasting. *Journal of Time Series Analysis*, 13: 353-75.
- [21] Rogoff, K. (1996), The Purchasing Power Parity Puzzle. *Journal of Economic Literature*, 647-668.
- [22] Steigerwald, D. G. (1996), Purchasing Power Parity, Unit Roots and Dynamic Structure. *Journal of Empirical Finance*, 343-57.
- [23] Stock, J.H. (1987), Asymptotic Properties of Least Square Estimators of Cointegrating Vectors. *Econometrica*, 55, 1035-56.
- [24] Wolters, J. (1995), On the Term Structure of Interest Rates: Empirical Results for Germany. *Statistical Papers*, 36: 193-214.
- [25] Wolters, J., T. Teräsvirta and H. Lütkepohl. (1998), Modelling the Demand for M3 in the Unified Germany. *Review of Economics and Statistics*, forthcoming.
- [26] Zhang, H. (1993), Treasury Yield Curves and Cointegration. *Applied Economics*, 25:361-367.